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Original Contribution

Timeliness of interfacility transfer for ED patients with ST-elevation myocardial infarction☆

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ABSTRACT

Objectives: Most US hospitals lack primary percutaneous coronary intervention (PCI) capabilities to treat patients with ST-elevation myocardial infarction (STEMI) necessitating transfer to PCI-capable centers. Transferred patients rarely meet the 120-minute benchmark for timely reperfusion, and referring emergency departments (EDs) are a major source of preventable delays. We sought to use more granular data at transferring EDs to describe the variability in length of stay at referring EDs.

Methods: We retrospectively analyzed a secondary data set used for quality improvement for patients with STEMI transferred to a single PCI center between 2008 and 2012. We conducted a descriptive analysis of the total time spent at each referring ED (door-in–door-out [DIDO] interval), periods that comprised DIDO (door to electrocardiogram [EKG], EKG-to-PCI activation, and PCI activation to exit), and the relationship of each period with overall time to reperfusion (medical contact-to-balloon [MCTB] interval).

Results: We identified 41 EDs that transferred 620 patients between 2008 and 2012. Median MCTB was 135 minutes (interquartile range [IQR] 114,172). Median overall ED DIDO was 74 minutes (IQR 56,103) and was composed of door to EKG, 5 minutes (IQR 2,11); EKG-to-PCI activation, 18 minutes (IQR 7,37); and PCI activation to exit, 44 minutes (IQR 34,56). Door-in door-out accounted for the largest proportion (60%) of overall MCTB and had the largest variability (coefficient of variability, 1.37) of these intervals.

Conclusions: In this cohort of transferring EDs, we found high variability and substantial delays after EKG performance for patients with STEMI. Factors influencing ED decision making and transportation coordination after PCI activation are a potential target for intervention to improve the timeliness of reperfusion in patients with STEMI.

1. Introduction

Timely reperfusion of ischemic myocardium is an important predictor of clinical outcomes for patients with ST-elevation myocardial infarction (STEMI) [1]. The preferred reperfusion strategy is primary percutaneous coronary intervention (PCI) [2], yet most US health care facilities lack primary PCI capabilities necessitating interfacility transfer [3]. Unlike patients with STEMI who directly present to a facility with

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PCI capabilities, transferred patients rarely achieve timely reperfusion due to delays in the transfer process.

Two process measures quantify the timeliness of care for patients with STEMI. Door-in door-out (DIDO) measures the length of stay at a transferring emergency department (ED). Maximum time goals are between 30 and 45 minutes, but neither was officially recommended in the latest STEMI guidelines [2]. Medical-contact-to-balloon (MCTB) measures the time from original contact at the transferring ED through myocardial reperfusion at the PCI center. The goal is for 90% of patients to achieve reperfusion within 120 minutes of first medical contact [2]. Although similar to the door-to-balloon process measure, which applies to direct presenters and has a 90-minute goal, MCTB only applies to transferred patients with STEMI [2].

Most patients presenting directly to primary PCI facilities meet the 90-minute door-to-balloon goal for timely reperfusion [4]. However, patients with STEMI requiring transfer, up to 45% in some regions [5,6], meet reperfusion goals for approximately 10% of transfers [7,8]. Compared with direct presenters, transferred patients experience significantly longer MCTB times and may benefit from targeted process improvement interventions designed to reduce delays to primary PCI [9].

The ED plays a central role in the timely care of patients with STEMI. Transferred patients who spent less than or equal to 30 minutes at a transferring ED (ie, DIDO) had a lower in-hospital mortality rate [10]. Most preventable delays occur at referring EDs (64%) rather than during transportation (13%) or the receiving PCI centers (16%) [11]. The 30-minute DIDO goal is only met for approximately 11% of transferred patients with STEMI [10,12]. Prioritizing process improvement efforts to reduce DIDO requires detailed measurements of the process steps at transferring EDs. However, collecting high-quality process data across multiple organizations can be challenging, further limiting analysis and process improvement efforts.

Large data sets (eg, ACTION Registry and the Center for Medicare and Medicaid Service Hospital Compare) collect limited process data on interfacility STEMI transfers. Detailed process timestamps enable the ability to pinpoint "where" and "when" delays occur and to better explain "why" delays occur in the transfer process. The ACTION Registry records only 3 timestamps of process steps at referring EDs: patient arrival, electrocardiogram (EKG) performed, and exit. As a result, only 2 time intervals (ie, door to EKG and EKG to exit) can be calculated to describe the referring ED length of stay. One of the activities and its associated interval, door to EKG, was already targeted by national process improvement efforts and is also part of the latest STEMI guidelines [2,13]. Efforts to quickly perform an EKG have improved the door-to-EKG interval and now represent a minor fraction of overall DIDO. The remaining time interval available in ACTION, EKG to exit, represents a large period that encompasses multiple processes including PCI center activation, patient preparation for transfer, transportation coordination, and exit from the referring ED.

The Centers for Medicare and Medicaid Services Hospital Compare database provides even less detail than the ACTION Registry. Hospital Compare reports OP-3B, "Median Time to Transfer to Another Facility for Acute Coronary Intervention," a measure equivalent to DIDO. No additional timestamps are available about referring ED length of stay. Therefore, these 2 data sets provide little detail to adequately describe the processes that occur at referring EDs.

Further dissection of the processes after the performance of an EKG in patients with STEMI may enhance our understanding of this period, better identify potential sources of delays, and prioritize process improvement efforts. To conduct such an analysis, we used an existing quality improvement hospital data set tracking patients with STEMI transferred to Vanderbilt University Medical Center (VUMC) for primary PCI. We then discuss implications for evaluating referring ED performance and intervening to improve it.

2. Methods

2.1. Study design and population

We used an existing cohort of patients with STEMI who was transferred to a single primary PCI center (VUMC), for our analyses. Originally developed in 2007 as part of an ongoing quality improvement initiative, the STEMI transfer database began data collection in the fourth quarter of 2007. We received separate institutional review board approval from the Vanderbilt University Institutional Review Board for this study.

Even if patients with STEMI bypassed the ED, the transfer database includes all patients with STEMI who were transferred to VUMC for primary PCI. For the present analysis, we included only patients with STEMI transferred between January 1, 2008, and December 31, 2012. We excluded patients who received fibrinolytics, which are recommended, when the anticipated delay to primary PCI is greater than or equal to 120 minutes [2]. We excluded "scene STEMI" patients transported directly to VUMC from the field bypassing a referring ED. Finally, we excluded patients who did not have complete referring ED time interval data (ie, DIDO).

2.2. Data collection

Documents providing details and timing of care before and at VUMC are regularly collected and scanned into the VUMC electronic health record. A clinical study nurse then uses the VUMC electronic health record to complete a data dictionary and case report form with Research Electronic Data Capture [14], a secure browser-based metadata-driven electronic data capture tool. If data were not available, the clinical study nurse attempted to collect records from the referring facilities and transporting agencies. Operational data included emergency medical services (EMS), referring hospital, cardiac catheterization laboratory, and transportation interval timestamps. Clinical data included presenting symptoms, demographics, medical history, procedures, in-hospital outcomes, originating facility, and distance (using Google Maps) to VUMC.

2.3. Data analysis

For the present study, data were provided as a deidentified data set. Time intervals were precalculated as the difference between 2 timestamps to remove protected health information. We deconstructed DIDO according to the following time intervals for care at the referring ED: door to EKG, EKG-to-PCI activation, and PCI activation to exit as seen in Fig. 1. Each time interval was calculated using the following approach. The door-to-EKG interval was calculated as the maximum of the door-to-EKG interval or zero. Values were set to zero if the door-to-EKG interval was negative suggesting that the EKG was performed before arrival at the ED. The EKG-to-PCI activation interval was calculated as the door-to-PCI activation minus the calculated door-to-EKG interval. Finally, the PCI activation-to-exit interval was calculated as the overall ED length of stay (ie, DIDO) minus the door-to-PCI activation interval. We did not perform imputation for missing transportation and cath laboratory values.

We used an established zone classification system to distinguish facilities by distance [15]. Zone 1 facilities are less than 60 miles from the PCI center, and zone 2 facilities are between 60 and 210 miles from the PCI center. We also quantified the number of STEMIs transferred by facilities for each year.

To evaluate whether transferred patient demographics and timeliness changed during the study period, we calculated and compared patient populations and timeliness performance using Kruskal-Wallis (for continuous variables) and Pearson χ^2 tests (for categorical variables). Significance was set a priori at 0.05. For the 7 time intervals, we corrected for multiple comparisons using the Bonferroni method with a revised significance level of 0.007 (0.05/7). Next, to quantify differences in referring ED timeliness, analyses included both numeric and graphic methods to detail